Image-Based Modeling and Photo Editing

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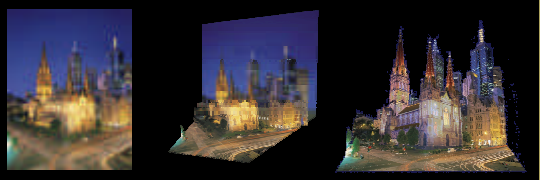
Introduction: Image-Based Editing

Single image as input
Editing of image-based representation



Input image | New viewpoint | Editing, relighting

Image-Based Modeling & Rendering

Rendering new views
- Chen et al.93, Laveau et al.94, McMillan et al.95, Levoy et al.96, Gortler et al.96, Horry et al.97, Shade et al.98

3D models from photographs
- Debevec et al.96, Faugeras et al.95, Poulin et al.98, Liebowitz et al.99

Unfortunately, little work in editing
- Seitz et al.98

Photo Editing

Powerful *editing* systems
- e.g. Adobe Photoshop, Gimp

Completely based on user intervention

Unfortunately, limitations of 2D

Goal: Best of Both Worlds

Image-based modeling & rendering
- Capture 3D layout, render new views

Photo editing
- Editing, flexibility, simplicity

Image-based *editing*!

Sample Result of Our System

Input Image, Courtesy of Barry Webb and Assoc.

Outline

Image-based representation & user workflow
Depth assignment
Non-distorted clone brushing
Texture-illuminance decoupling

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Image-based representation & user workflow
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Image-Based Representation

Build upon *images with depth* (Chen & Williams 93)


Color channel Depth channel

Image-Based Representation

Layers of images with depth

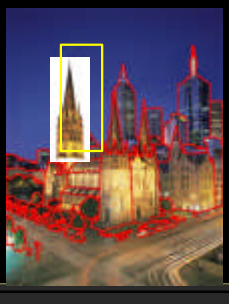

Image-Based Representation

Layers of images with depth
Each layer has

- Color
- Depth
- Transparency

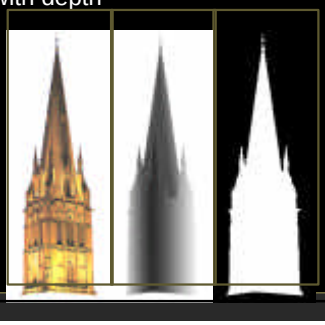

Image-Based Representation

Layers of images with depth
Each layer has

- **Color**
- Depth
- Transparency

Image-Based Representation

Layers of images with depth

Each layer has

- Color
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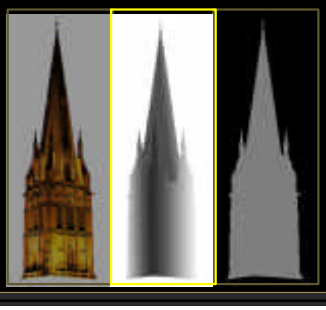

Image-Based Representation

Layers of images with depth

Each layer has

- Color
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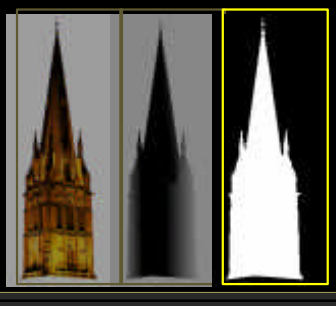


Typical User Workflow

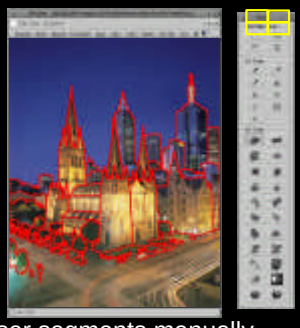
Input image

Typical User Workflow

Input image

Typical User Workflow

Input image

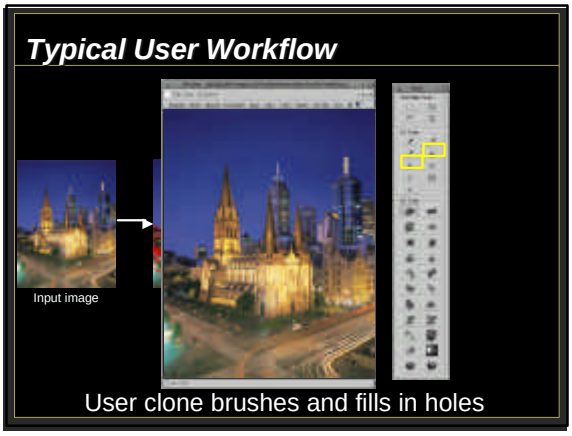


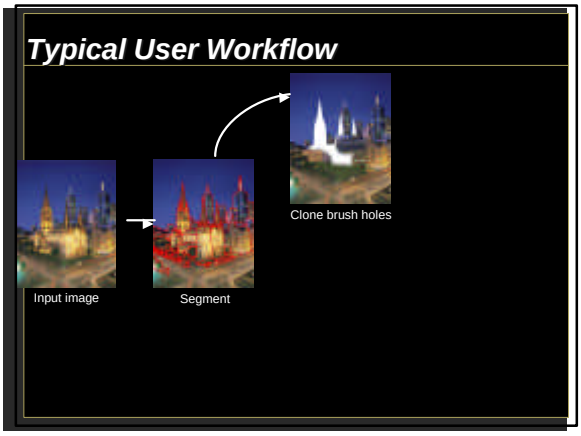
User segments manually

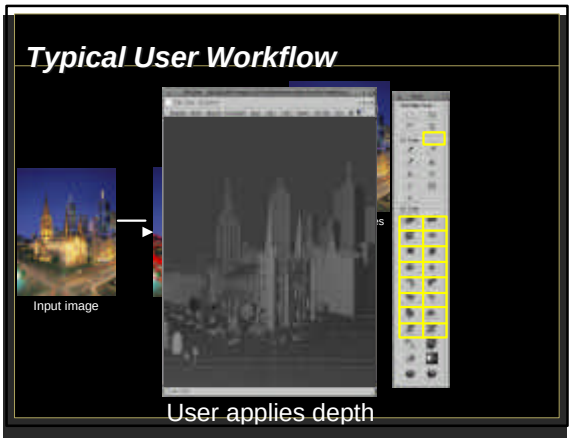
Typical User Workflow

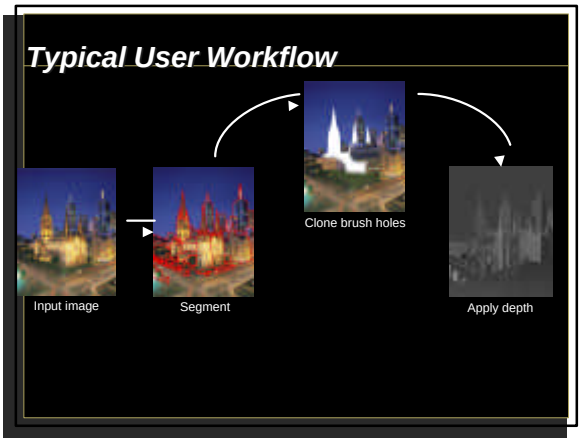
Input image

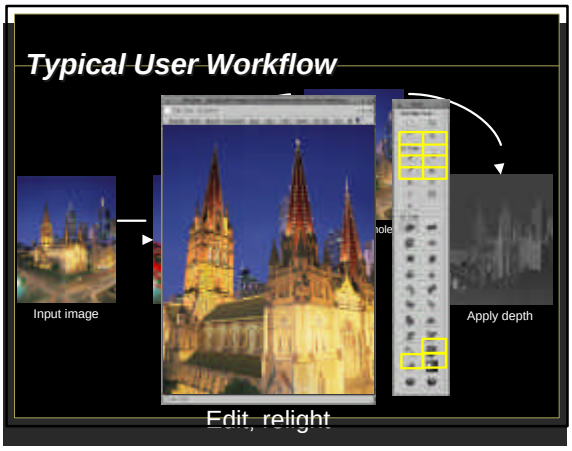
Segment

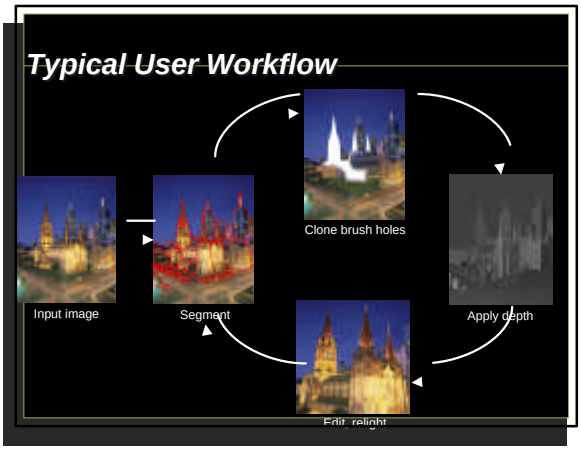

Typical User Workflow
Input image
User clone brushes and fills in holes


Typical User Workflow
Clone brush holes
Input image
Segment


Typical User Workflow
Input image
User applies depth


Typical User Workflow
Clone brush holes
Input image
Segment
Apply depth


Typical User Workflow
Input image
Apply depth
Edit, relight


Typical User Workflow
Clone brush holes
Input image
Segment
Apply depth

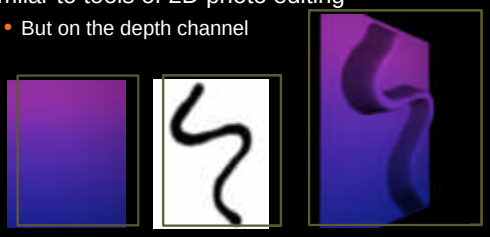
Outline

Image-based representation & user workflow
Depth assignment
Non-distorted clone brushing
Texture-illuminance decoupling

Depth Assignment Tool

Tool that assigns or modifies the depth of pixels
Similar to tools of 2D photo editing

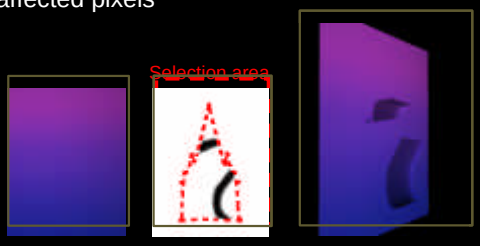
- But on the depth channel



Color channel Depth channel Side view

Depth Assignment and Selection

Arbitrary selection/segmentation restricts the affected pixels



Color channel Depth channel Side view

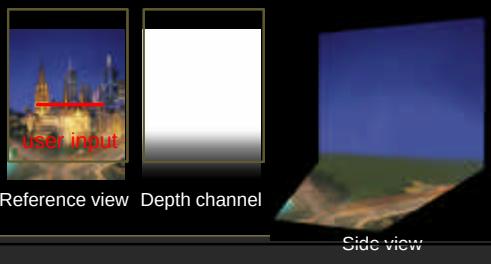
Going Beyond Painting

- Painting absolute depth is hard
- Hybrid geometric tools
  - But still pixel based (flexible, use of selection)
  - Geometry is temporary

Update depth

Ground Plane Tool

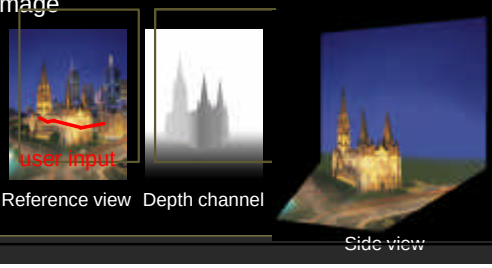
The ground plane is easy to infer (horizon)
Will be used as a reference



Reference view Depth channel Side view

Vertical Tool

Uses ground plane as reference
Draw contact between ground and object in image

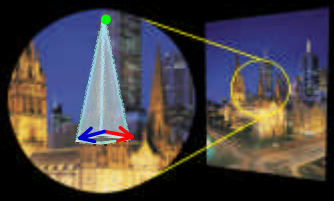


Reference view Depth channel Side view

Geometric Primitives

Sphere, cylinder, box, pyramid, etc.

Possible snapping to constrain verticality



Organic Shapes

Level set method (Williams et al.98,Igarashi et al.99)

Distant depth at boundary, closer depth towards center

Layer Depth channel

Generic Geometry Tool

3D template

User defined point correspondences

3D pose optimization

Refinement through 2D morphing

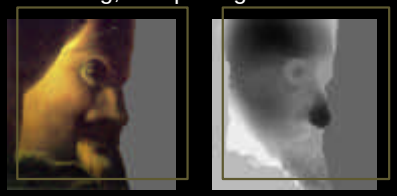
User defined point correspondences Optimized pose Side view

Depth Painting & Chiseling

Paint on depth channel (Kang 98)

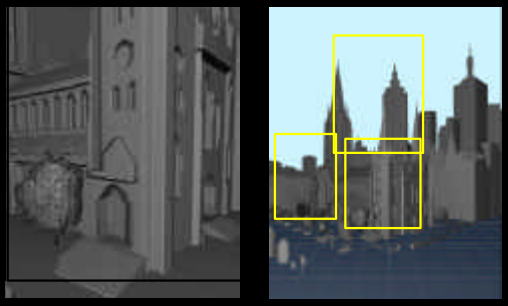
Relative or absolute

Local smoothing, sharpening



Layer Depth channel

Refined Example



Refined depth

Outline

Image-based representation & user workflow

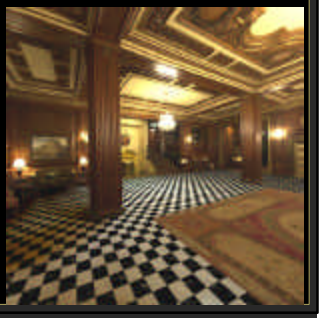
Depth assignment

Non-distorted clone brushing

Texture-illuminance decoupling

2D Clone Brush

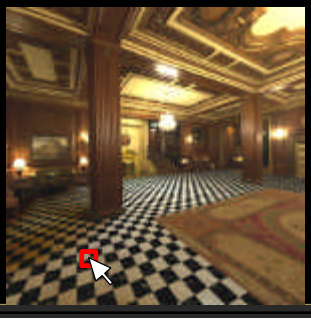
Copies via brush interface



2D Clone Brush

Copies via brush interface

source pixel

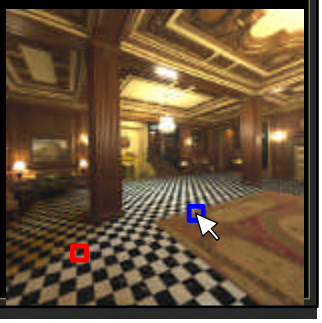


2D Clone Brush

Copies via brush interface

source pixel

destination pixel

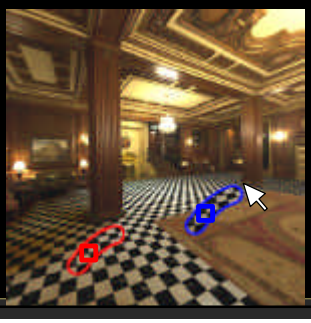


2D Clone Brush

Copies via brush interface

source pixel

destination pixel



2D Clone Brush

Copies via brush interface

source pixel

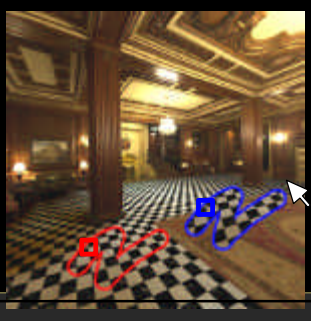
destination pixel

2D Clone Brush

Copies via brush interface

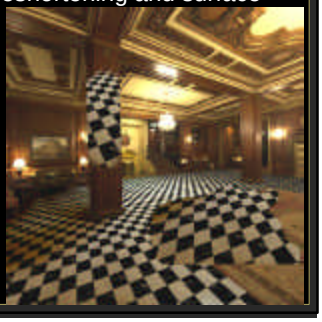
source pixel

destination pixel



Limitations of 2D Clone Brushing

Distortions due to foreshortening and surface orientation



Goal

Cope with

- Foreshortening
- Surface orientation

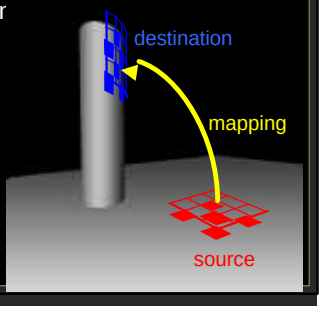
Coping with Distortions

Determine a mapping between pixels of source & destination regior

Minimize distortion

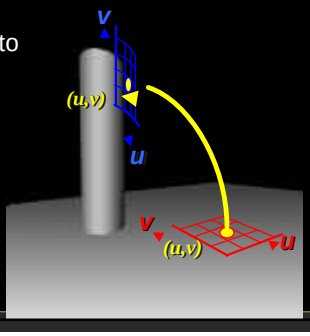
- Foreshortening
- Surface orientation

Arbitrary geometry



Parameterization

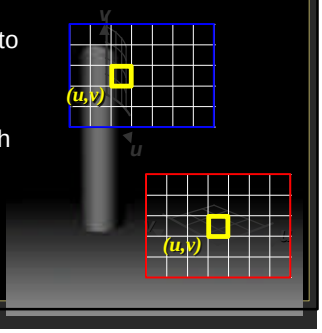
Map UV conforming to geometry



Parameterization

Map UV conforming to geometry

Compute UV for each pixel



Parameterization Optimization

Lévy & Mallet (1998)

- Iterative optimization
- Minimizing angular and iso-line distortion

Differences

- Real time
- No boundary conditions

Extensions to Lévy & Mallet's Work

Expanding *active region*

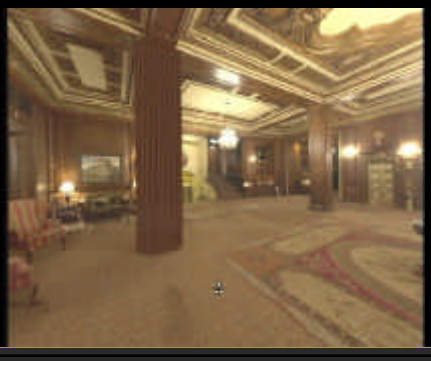
Optimization proceeds as user clone-brushes

Freeze parameters of brushed pixels

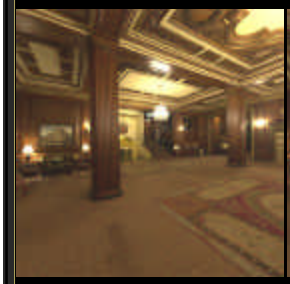
Acceleration

- Sub-sampling
- Smart UV initialization

Parameterization Visualization



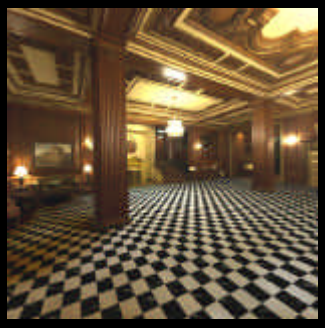
Examples



Initial image

Clone brushed image

Examples



Outline

Image-based representation & user workflow
Depth assignment

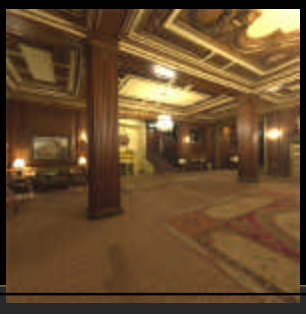
Non-distorted clone brushing

Texture-illuminance decoupling

Motivation

Changing materials

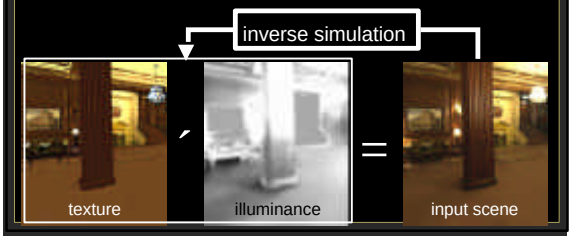
Relighting



Inverse Lighting Simulation

Physically-based approaches

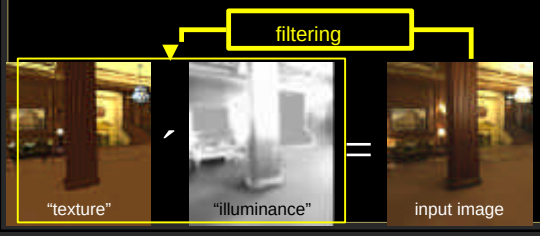
Fournier et al.93, Drettakis et al.97, Debevec.98, Yu et al.99, Loscos et al.99, Loscos et al.00



Texture-Illuminance Decoupling

Not physically based

- Our “texture” and “illuminance” are reasonable estimates

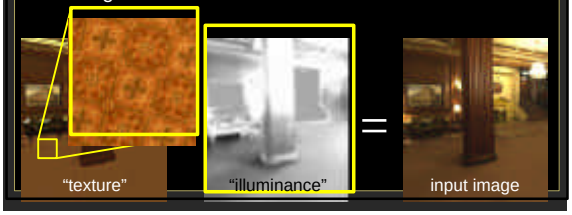


Texture-Illuminance Decoupling

Not physically based

Assumptions:

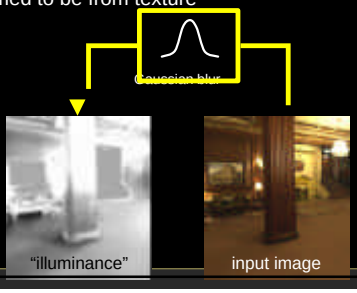
- Small-scale features → “texture”
- Large-scale features → “illuminance”



General Idea: A Naïve Approach

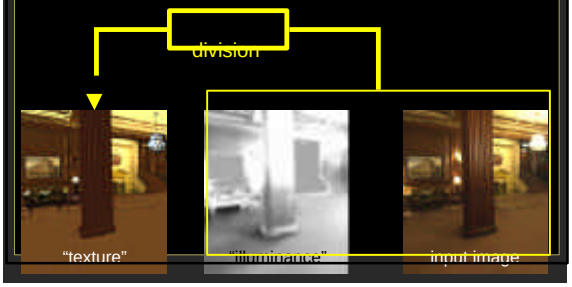
Large-scale features using low-pass filter

- Color is assumed to be from texture

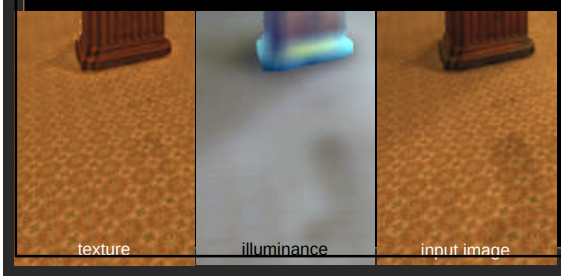


General Idea: A Naïve Approach

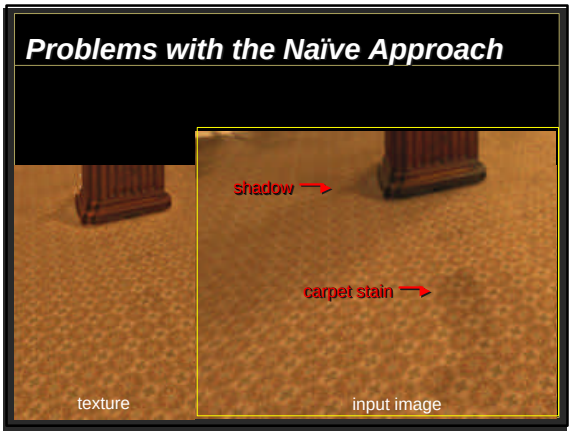
Extract texture from illuminance and input image



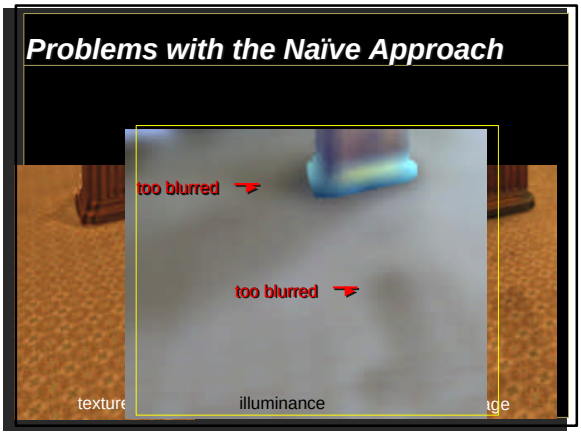
Problems with the Naïve Approach



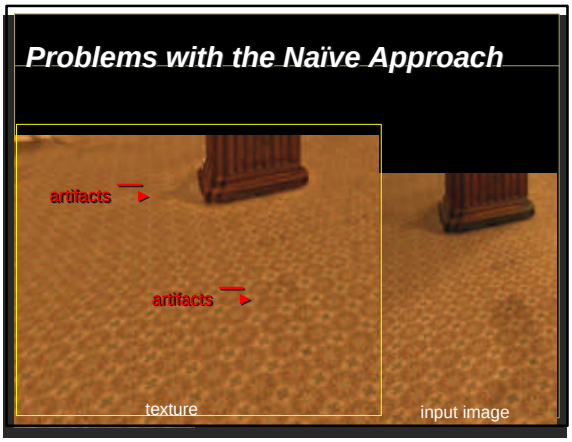
Problems with the Naïve Approach



Problems with the Naïve Approach

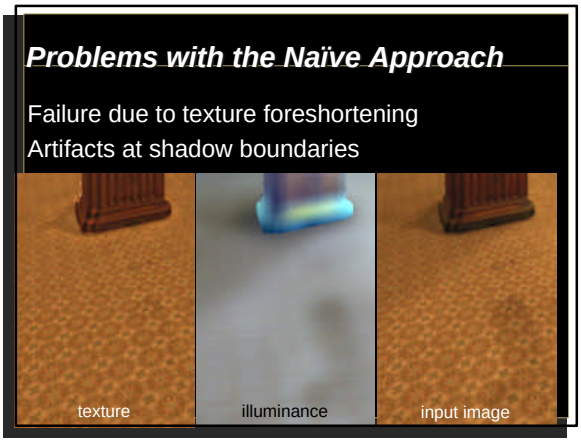


Problems with the Naïve Approach

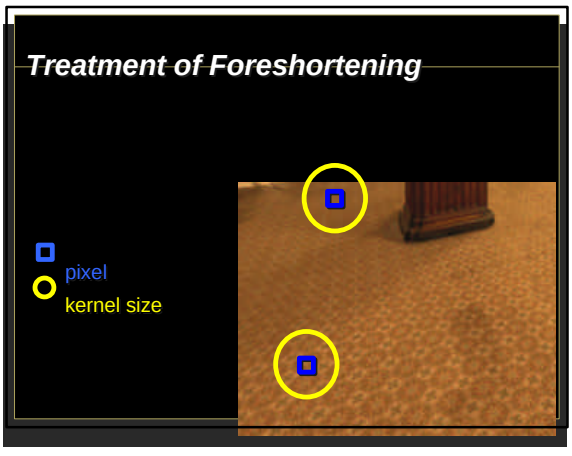


Problems with the Naïve Approach

Failure due to texture foreshortening
Artifacts at shadow boundaries

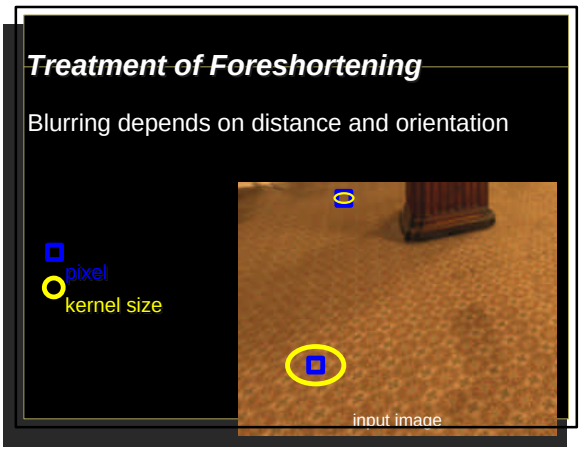


Treatment of Foreshortening

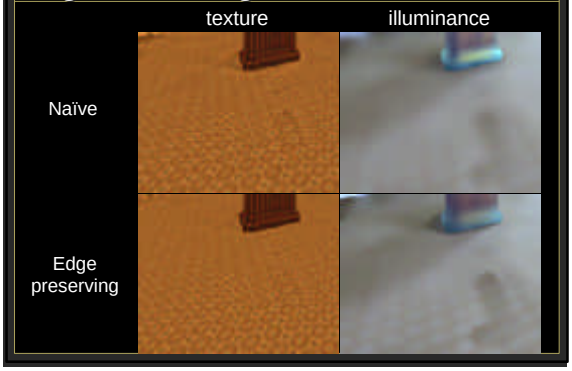


Treatment of Foreshortening

Blurring depends on distance and orientation



Edge-Preserving Filter



A Simple Relighting Example

Results – Hotel Lobby

Results – A Painting by Dali

Conclusion

Image-based modeling & photo-editing system
Single image as input
Layers of images with depth
Depth assignment tools
Non-distorted clone brushing
Texture-illuminance decoupling

Future Work

Incorporate other techniques
- e.g. shape from shading, stereo, filters

Multiple images
- For modeling & larger walkthroughs

View-dependent effects
Applications
- e.g. special effects, design, virtual TV sets

Thank You

Aparna Das
George Drettakis
Steven Gortler
Rujira Hongladaromp
Nicolas Tsingos
Neel Master
Leonard McMillan
Sini Kamppari
Barry Webb and Assoc.
Alex Wong

Pixar Animation Studios
NSF CISE Research Infrastructure Award